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(54) More-vibration-free concrete breakers and percussion drills

(57) In order to reduce vibration on concrete breakers and percussion drills, a system for internal absorption of recoil is devised.

Accordingly Fig 1 is a diagrammatic representation of a basic device to be incorporated in the "drill" design. MP2 is a mass which absorbs the recoil and can then return to add impact to the tool on the next stroke. C3 is the main "tuning" compliance. The "explosion" chamber is the volume around C4. It is shown how this system can produce a breaker that can approach zero recoil vibration and simultaneously be lighter in weight.

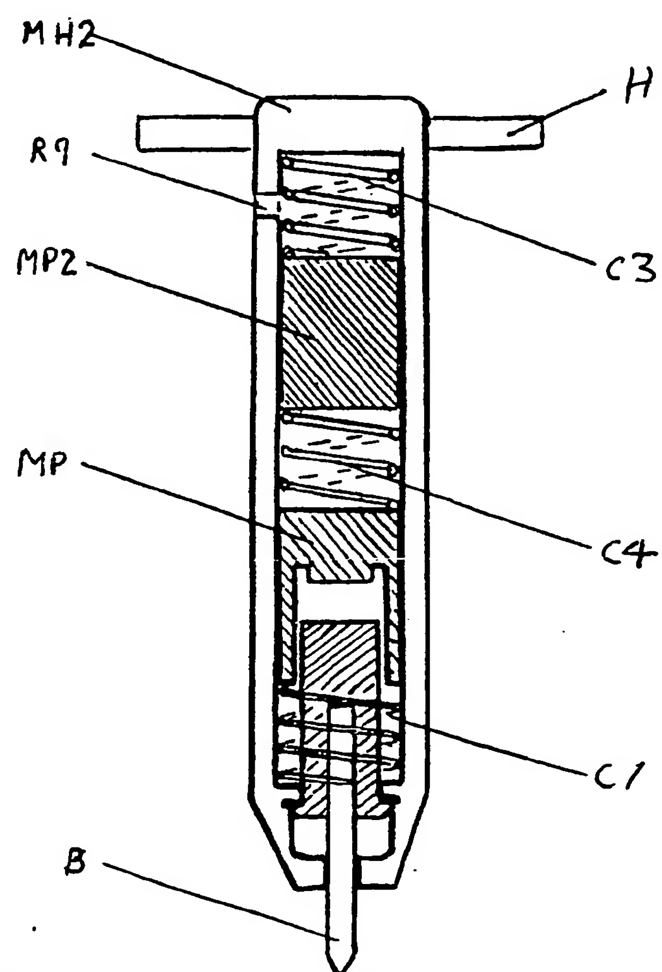

FIG. 1

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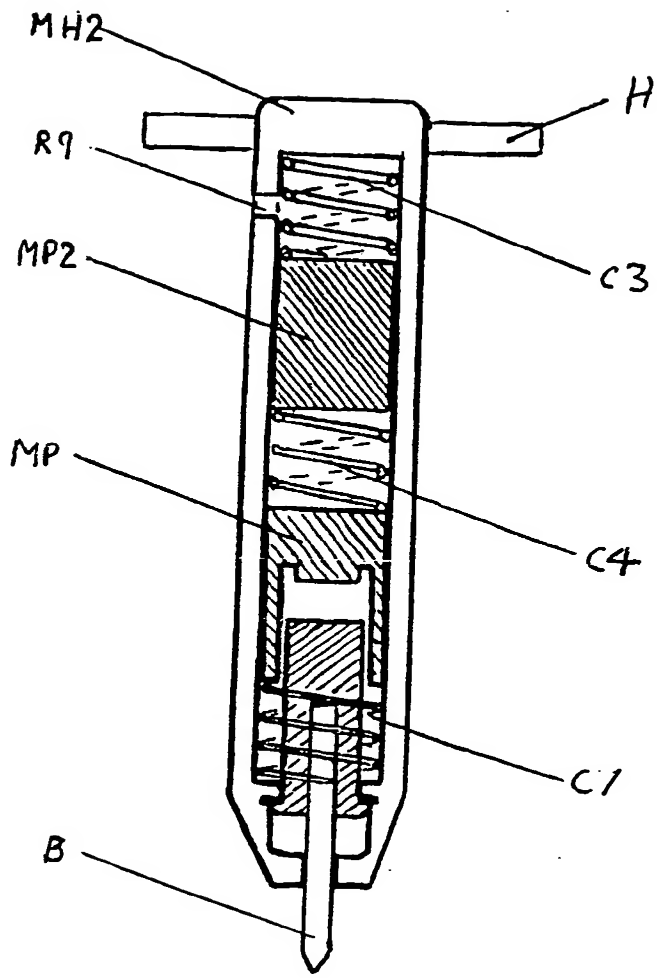


FIG. 1

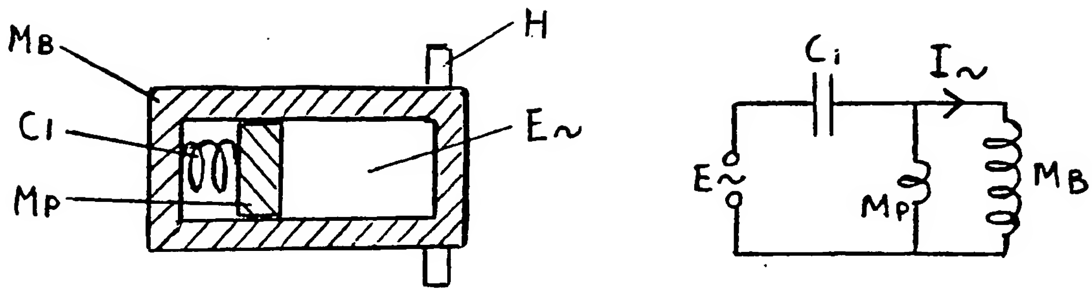


FIG 2

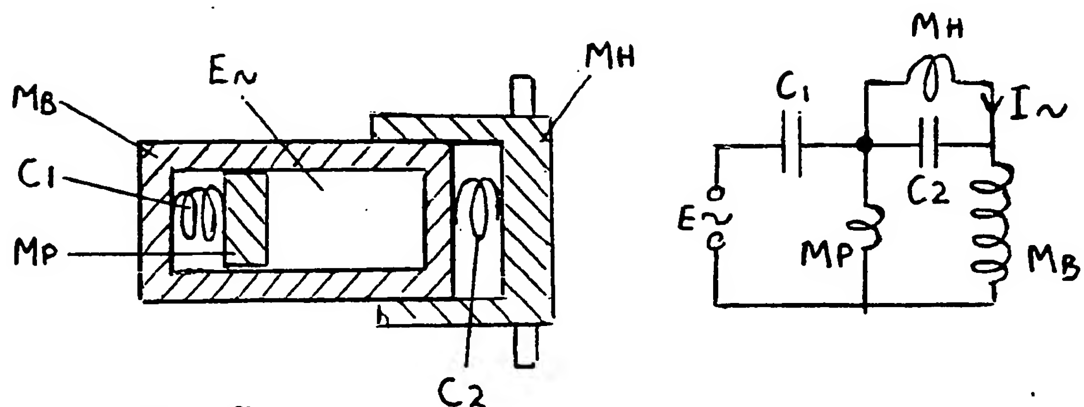


FIG 3

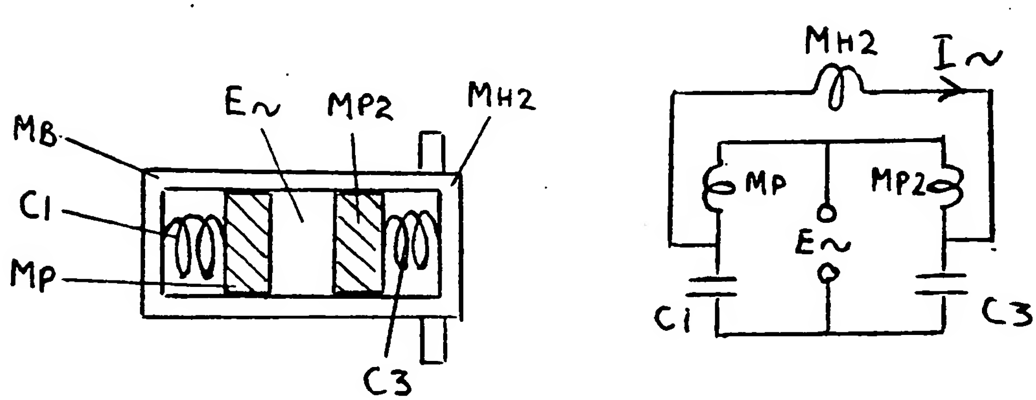


FIG 4

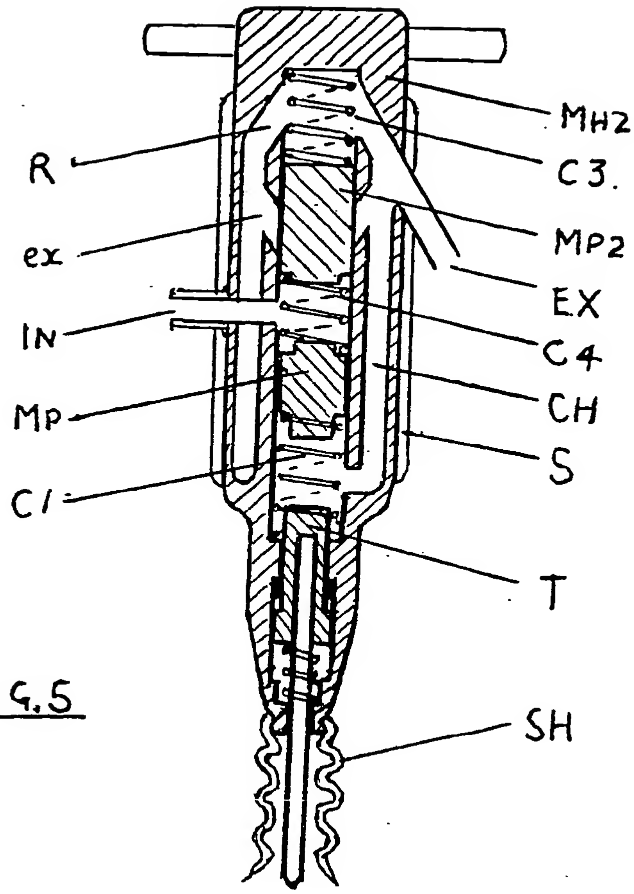


FIG.5

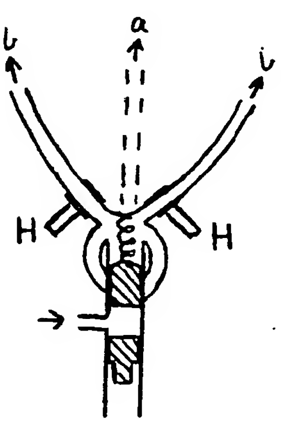
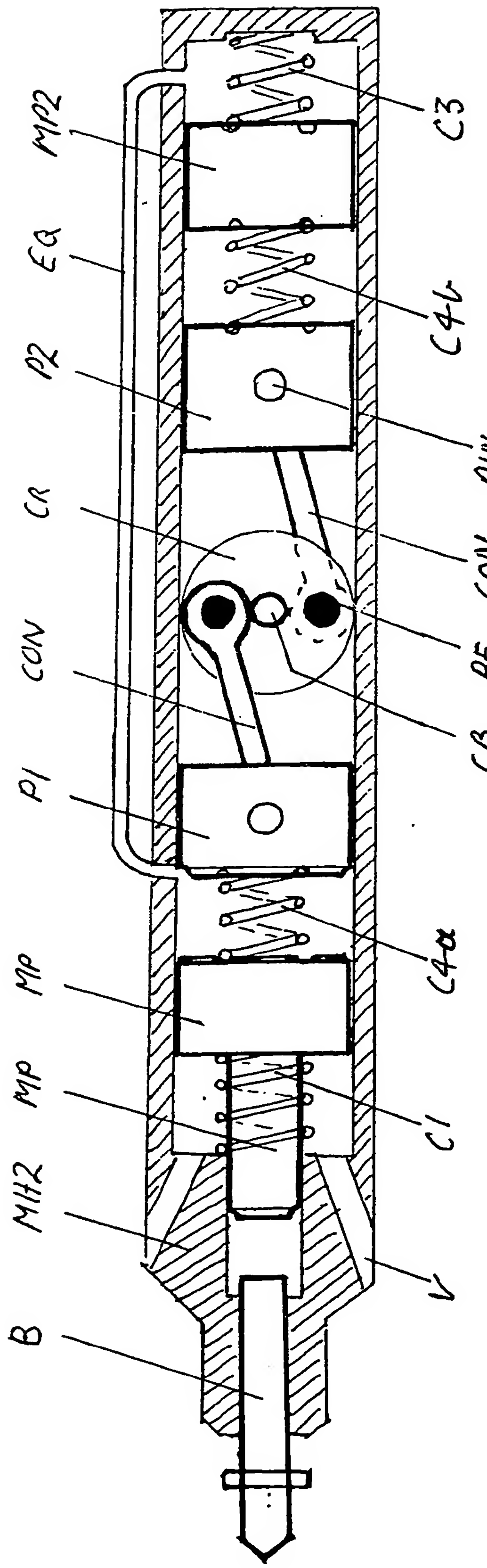
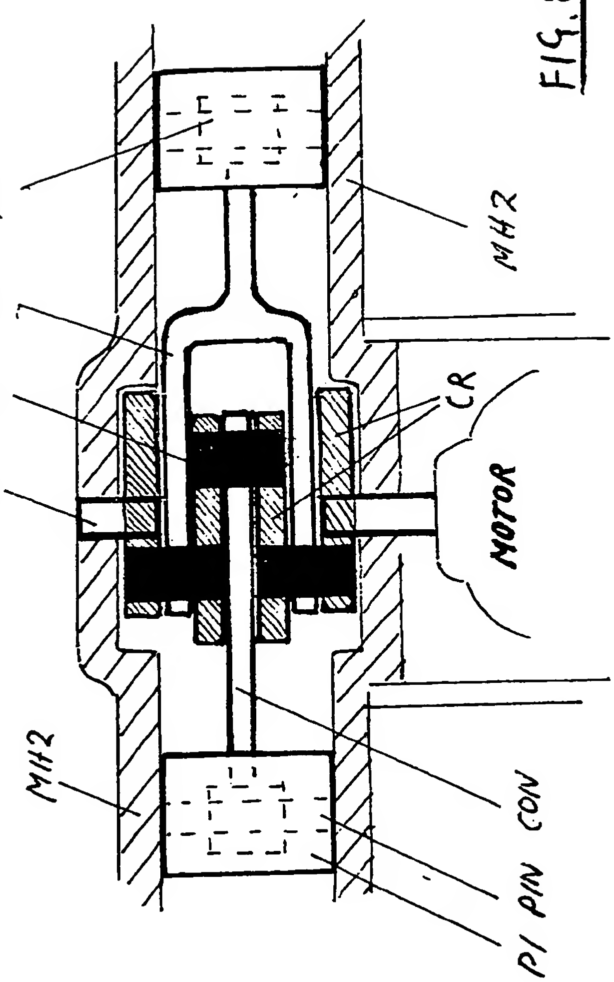


FIG.6



MP2
EQ
P2
CR
CON
P1
MP
MP
MH2
B
C3
C4b
PIN
CON
BE
CB
C4a
C1
V

FIG.7



PIN
CON
MH2
CR
MOTOR
MH2
P1
PIN
CON

FIG.8

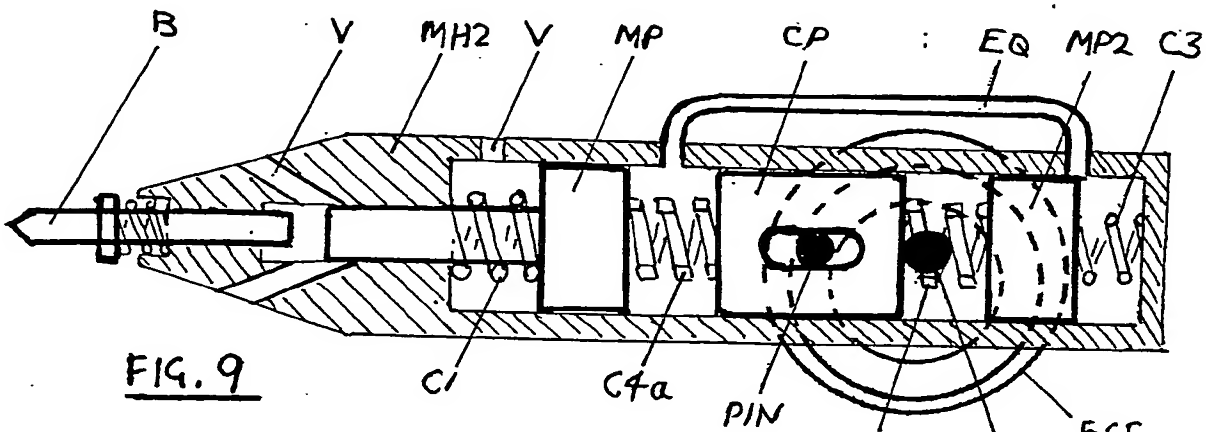


FIG. 9

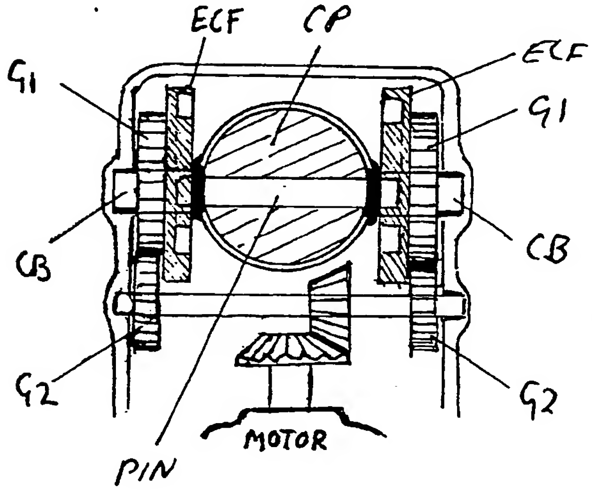


FIG. 10

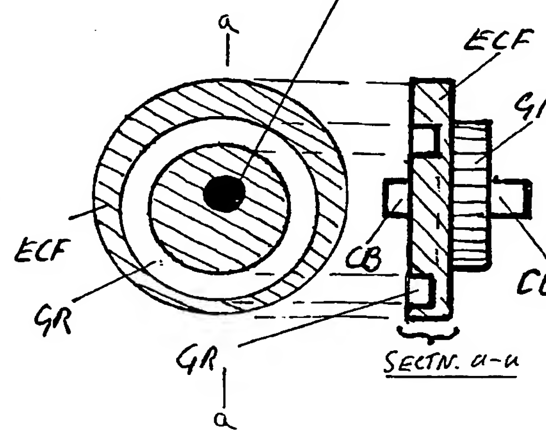


FIG. 11

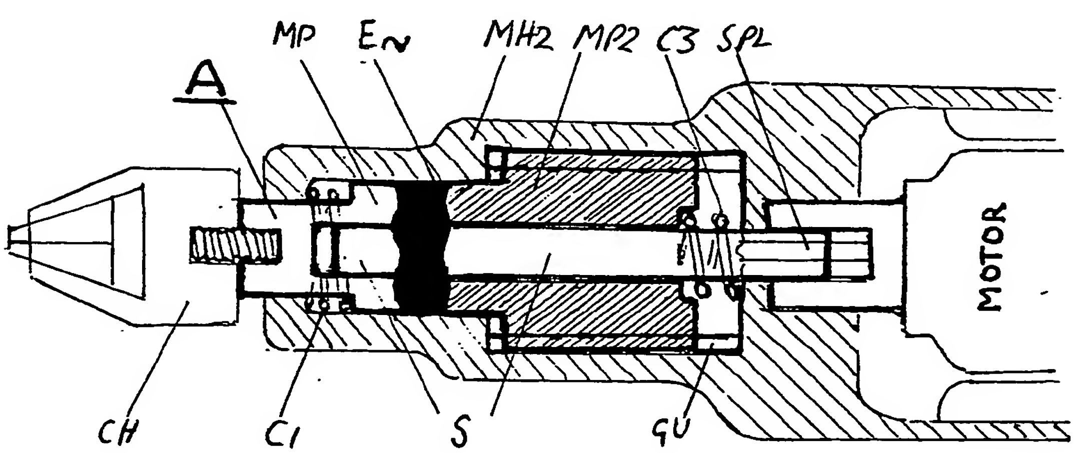


FIG. 12

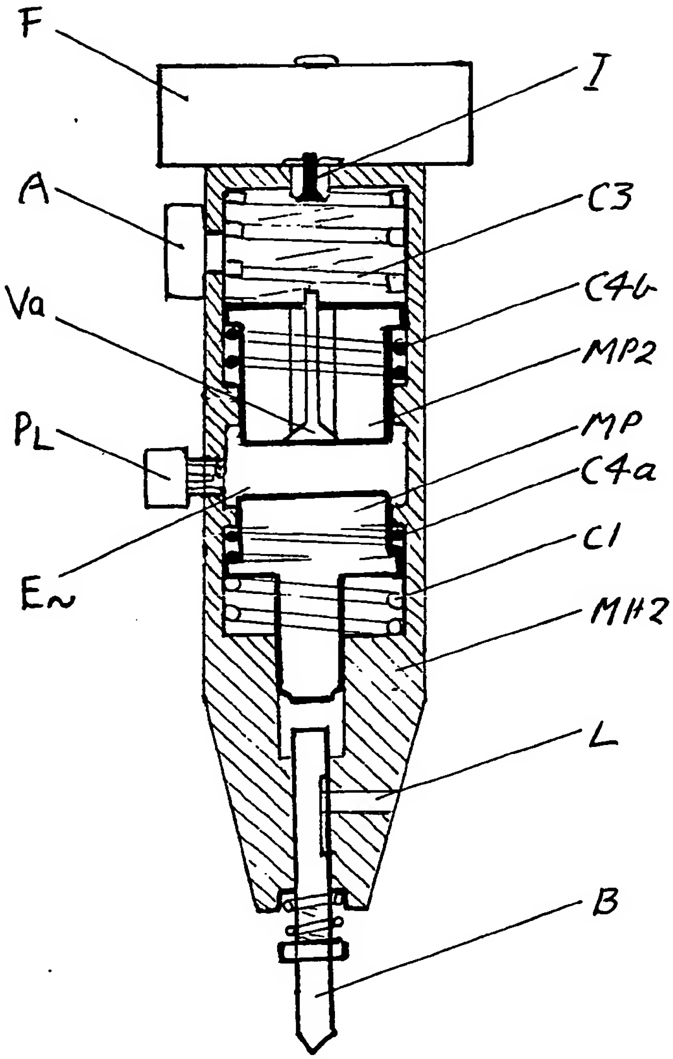


FIG. 13

SPECIFICATION

Quieter & more vibration-free percussion drills & breakers

Existing percussion drills and concrete breakers affect the operator with their vibration, and the latter are noisy. A system is here described which is designed to balance the reaction to the driving impact on the power source, within the drill or breaker itself instead of by the operator. This reaction balancing, better enables design of resonances to return some vibration energy losses to the cutting tool.

Figure 1 is a diagramatic representation of the first basic device which is to be incorporated in the design of such a "drill" or "breaker" system. The valves, and existing known means of causing the operation of the tool, are not shown for reasons of simplicity and clarity.

M2H is the drill body with two handles H, and cutting-tool B. MP2 is a heavy mass whose position and time constant of oscillation is controlled largely in relation to the spring C3 or other source of compliance. MP is the mass for the piston-tool-drive system, with its compliant suspension and positioning elements C1 and C4 which also affect the period of vibration of MP and MP2. The power or pressure source is via the "explosion chamber" in which C4 is shown.

It will be seen that MP2 and C3 can be "tuned" to have a similar time-constant to MP and C1. This can also be modified by the orifice R9. The "firing-time" which is arranged to occur in-phase with the return of MP, can thus be made coincident with or before MP2 has returned to its "rest position", and thus the "explosion" (pressure impulse) in the central chamber surrounding C4, is met at the upper end with the inertia or momentum of MP2 in the opposite direction. IE, Mp2 offers a mass impedance which takes the recoil instead of the holding-case MH2, and where C3 is a compliant "by-pass" of the recoil motion of MP2 past MH2.

The position, use, shape and size of orifice R9 can also be used to modify the instantaneous velocity of MP2 at any part of its motion,

MP and C1, and MP2 and C3, can be proportioned for little or no extra loss of tool impact over the usual arrangement that is without MP2. These "losses" however can now be made to occur in the tool body rather than in the operator. The overall weight of the breaker may also be reduced if need be. In fact variations of performance characteristics may thus be designed or variably controlled if and as required.

By way of further explanation of the basic principles, Figures 2, 3 and 4 show first approximations to the basic functional differences between this device and previous devices. Accordingly Figure 2 shows the usual existing form of road breaker, in which a cylinder body Mb contains an "explosion chamber" E~, a hammer-piston Mp, and a return force for this piston, here supplied by spring C1. "H" are the handles for operator support.

The accompanying electrical analogues of these mechanical systems bear the same monenclature.

The main 'first approximations' are in consideration that the hammer Mp strikes the cutting-tool, whilst the former is in "free-flight" when the driving pressure has been released by the opening of the exhaust valve. E~ represents the cyclical force of the "explosion", and the current I~ represents the vibratory motion (velocity) of the breaker body and/or its handles.

It is clear that in this normal type of breaker, that the handle vibration is inversely proportional to the weight of the breaker body, whereas the efficiency is proportional to that weight.

Figure 3 shows an existing method of reducing the vibration of the handles through the intervention of a compliant member C2 between body Mb and handle mass structure Mh. This if MH 2 are not "tuned" leads to an even heavier machine for the same efficiency.

Figure 4 shows the basic concept of the present invention, where Mp2 and C3 are introduced into the cylinder and the electric circuit analogue then takes the form of an electrical "bridge", which for a completely balanced system I~ is zero and vibration thus completely eliminated even where the breaker body mass is also practically zero.

To a second approximation, it is clear that the impact of the hammer piston upon the cutting tool, and the consequent sudden arrest of that piston, will cause a reaction of the expanding gasses, with a resultant reaction in the opposite direction, ie upwards against the body of the breaker, via the exhaust system. But since this coincides with the exhaust release, this already lesser, secondary reaction is somewhat relieved in assisting rapid exhaust process. From here, exhaust tuning may be used to further reduce this secondary reaction.

This exhaust tuning might be accomplished by simple use of an "expansion chamber" where the gasses can be made to resonate at the appropriate frequency by well-known practice. The motion of the rear end of Mp2 can also be arranged to provide a similar facility, this time of a second exhaust cycle for instance, in different phase to the main outlet from the explosion chamber, so that a smoother exhaust, which is also effectively at double the frequency and easier to silence.

Other methods of reducing noise, by using the exhaust expansion chamber as an overall shroud round the breaker body, and by use of a suitable covering membrane in the same way, are also convenient on this lighter breaker body. Similarly the inter-action between the "explosion" chamber and "expansion chamber" temperatures by such shrouding, could be useful in reducing "icing" effects.

Finally a tool-shroud to mask the noise of impacts between tool and work piece, may be easily attachable and detachable according to cutting use and according to environmental noise reduction requirements. Such a shroud would compliantly extend beyond the end of the tool, and would be made of thick tough and heavy material. "Neoprene" rubber preferably with some heavy "filler" would be one example of such material. Although this item in particular could be fitted to existing "drills", its

application on the above system would be more effective and appropriate, since other drills have other predominating noise sources.

Figure 5 is an embodiment in principle of a road-breaker that incorporates the above main features. It has the same nomenclature as Figure 4, plus the following:- "In" is the inlet to the "explosion" chamber containing C4 which separates the two pistons. "EX" is the exhaust outlet, "ex" is the internal exhaust outlet from the "expansion chamber". "R" is the 'intercycle' exhaust outlet mentioned above as being 'rear of Mp2'. "CH" is the "expansion chamber" which surrounds the whole cylinder. "T" is the tool-holding anvil. The tool shroud is "SH". "S" is a noise-deadening membrane round the main body.

Figure 5 also includes an aspect of a further development in which the exhaust outlets "ex" which connect to the expansion chamber, also allow the escape of gasses from the "explosion" chamber, to suddenly raise the pressure behind Mp2, causing in-effect an impact on Mp2, which can be arranged to coincide with the impact of Mp on the tool-anvil. The reaction of this upper impact is partly on a moving mass of air in the exhaust tube, and not entirely on the "drill" body. Thus the 2ndy reaction balance of the two pistons can be better maintained for less pneumatic reaction on the handles.

This principle may be extended to cause no major change of direction of the gasses behind Mp2, and thus further reduce their forces on the "drill" body.

This latter, generally impractical arrangement, with a vertical exhaust tube, may have limited application, and the otherwise single vertical exhaust tube "a" could alternatively be divided into two section "b" as in Figure 6, so that the tubes pass either side of the operator above head height, and the handles H are then more conveniently arranged for easy hold position from these tubes than the present straight patterns. The exhaust tubes might also give a convenient shoulder-rest position for the drill, whilst allowing a small degree of sideways manipulating movement of the drill.

Figure 7 depicts in schematic section the same basic principles already described, but here embodied in percussion drills powered by electric motors.

The same designations are used in Figure 7 as in Figures 4 and 5 as far as the basic or common elements of the "invention" are concerned, Eg the tubular body MH2, tool-bit B, primary tool-driving piston MP, and compliant member C1. Also secondary piston MP2, and compliant member C3, to resonate in balancing reaxtion to piston MP. C4a and C4b have a function which can be compared with C4 of Figure 5 in maintaining Mean static positions of MP and MP2.

The usual single piston P1 with its single con-rod and crank drive, is here elaborated into the balanced system with another piston P2, and a crankshaft driving these two pistons in opposite directions, so that the drive system itself achieves better balance. Again, the more commonly used drive systems in this electric type of percussion drill rely more on the compliant pneumatic forces for the function of C1 and C4a. But greater reliance on springs is preferred here because of their lower energy loss and more linear characteristics, which can be combined with the pneumatic characteristics where necessary.

EQ is an "equaliser" tube to allow some of the extra pressure created between piston MP and P1, when the tool is pressed against the workpiece, to be transferred to the rear of MP2 to provide a degree of mainly steady balancing pressure on the drive mechanism between pistons P1 and P2 and in fact between pistons Mp and MP2. This corresponds with the exhaust system described for Figure 5 as performing the same function. Vents "V" can be arranged where required to reduce pneumatic effects and provide "mechanical resistance" effects or free movement of air or gas, as required. Figure 7 does not show any bit-rotating mechanism as this can be achieved in the usual fashion without detriment to the invention.

Figure 8 shows the more balanced rotational system that is achieveable with the system of Figure 7 rather than the usual single piston drive system. The two bearing crankshaft has three "big-ends" BE, and four fabricated counterbalancing crank members CR.

Figure 9 depicts in schematic section a percussion system for a similar drill, but using a single but double-acting drive piston CP in its tubular body MH2. The pistons MP and MP2 here act together against the mass of drive piston CP, and to the extent that the system can work in suitably balanced resonance, the rotational device ECF should only need supply the losses incurred mainly during "drilling".

One advantage of this configuration compared with the single as usually used with a crank arm is the better all-round rotational balance achieveable with the slotted disc cams ECF of Figure 11, and the absence of any con-rod with its complex unbalance.

Figure 10 shows how such a sandwiched piston as CP in Figure 9 may be driven by the cams ECF, from the electric motor. Again Figure 9 does not show any bit-rotating mechanism.

Another advantage is its ability to use the pressure equaliser EQ described for Figure 7.

Figure 12 shows how the same balancing principles may be applied to the smaller type of hammer-drill in which a serrated disc E~ is driven to rotate to vibrate a similarly serrated face on part of the bit-holding mechanism MP, CH. Here the reaction is taken up by the mass of piston MP2, held from rotating by guides GU. Here the percussion drive shaft passes freely through MP2 to be driven by splines SPL on the motor shaft.

"A" is to draw particular attention to the fact that without the rotating drive to the chuck CH via its holder MP, the impact device is inoperative. Only when CH, MP are turned at different speeds or in opposite direction to E~ does the impact device come into operation. Also pressure from the tool bit increases the pneumatic pressure behind MP2.

Figure 13 depicts a basically similar form as shown in Figure 1 except that it is driven by internal combustion.

Liquid fuel such as petrol is kept in the container F and is drawn into the top chamber containing C3,

when piston MP2 travels down and reduces the pressure there so that the spring-loaded valve I is caused to open and admit a spray of fuel. Simultaneously air is drawn in via air filter A by the same reduced pressure.

When the piston MP2 is driven by the previous firing stroke, the mixture in chamber "C3" is compressed to a limited extent, then expanded, and on its rebound stroke where pressure in E~ is now reduced, the floating valve Va will open and admit a spray of mixture into the explosion chamber E~ so that on return of MP2 there will be some compression with enough pressure to operate the self-activating plug PL so that the mixture is ignited and piston MP2 driven up to repeat the cycle.

Thus a firing stroke every second stroke of the resonating piston MP2. The fact that the pressure-operated spark plug PL will fire every stroke will not matter as the unwanted firing will be in an environment of exhaust gasses.

The exhaust system is not shown but can be a commonly used type of sleeve valve constructed by appropriately placed holes in the piston sleeve of MP2 and also in the adjacent body of MH2. It is seen that the exhaust gasses will thus have escape on both strokes.

Such a pressure operated spark plug may not be well-known, but it is claimed in British Application 2,092,224 A. on "Fuel injection and spark plug ignition timing devices in I.C. engines".

CLAIMS

1. A percussion "drill" or "breaker" with or without means for rotating the tool bit, and comprising a body to hold the tool bit and a means of applying percussive or oscillatory forces onto the bit, and characterised in that the reaction on the driving source, from the linear reciprocating member or members or part thereof, which are used to transmit or impart force, impacts or oscillatory vibration to the working tool bit, is substantially balanced or absorbed by a similar linearly reciprocating member or members moving relative to the "drill" body and driven substantially in the opposite direction to that imparted by the driving source to the above-mentioned transmission members.

2. A percussion drill or breaker as in claim 1, where the driving source concerned is in the form of pneumatic pressure, internal combustion, hydraulic, mechanical, electro-mechanical, electro-magnetic, or magnetostrictive systems or combinations thereof, that can or could react upon the drill body, and where the reciprocating mechanism may be purely linear, or rotary-determined, or determined by cam, crank or serrated disc.

3. A percussion drill or breaker as in claims 1 or 2, where any part of the reciprocating, absorbing, or balancing mechanism can be tuned to resonate within a range of frequencies relevant to the function of that mechanism.

4. A percussion drill or breaker as in claims 1, 2 or 3, where the cycle of the absorption or balancing mechanism can have its reaction appropriately modified according to the pressures or losses imposed by the work piece and/or tool bit, by communication of such pressures or losses to the absorption/balancing mechanism via a reaction of the reciprocation- percussion mechanism.

5. A pneumatic, hydraulic, or internal combustion device as in claims 1, 3, or 4, where the motion of the absorbing or counterbalancing mass is used to assist escape of exhaust gasses.

6. A drill or breaker as in any of the claims 1 to 5, in which exhaust escape gas is used to cause a rise in pressure that opposes the outward motion of the absorbing piston so that it experiences a retarding force.

7. A drill or breaker as in claims 1 to 6, where movement of the absorbing or balancing mass is controlled or modified by the use position, shape or size of an orifice or chamber between the mass and its guiding structure, or in the guiding structure.

8. A shroud which can be fitted to the tool-bit or body of a drill or breaker, when it is required to mask noise emanating from the exposed part of the cutting tool or the immediate vicinity of the "cutting" process.

9. A drill or breaker as in any of the claims 1 to 8, in which pistons are driven in opposing directions by meams of a crankshaft.

10. A drill or breaker device as in claim 9, in which further moving piston masses are inserted in the oscillating "circuits" so as to counterbalance motion of the "ram" which is caused to impart impacts to the tool bit.

11. A drill or breaker as in any of the claim 1 to 10, where a tube or orifice, piston or electrical device, which responds to the pressure applied to the tool bit when cutting, and imparts this pressure or some of it, to the balancing mechanism so as to promote better dynamic balancing of the system.

12. A drill or breaker otherwise as in any of claims 1, 2, 3, 4, 7, or 11, except in which a single piston is driven to activate both the oscillating force on the bit, and also drives another piston and compliant member, which form together with the single drive piston a resonant oscillating device that can be "tuned" to the frequency imparted to the drive positon by the driving source, and whose motion can be controlled as in claims 11 and/or 4.

13. A device as in claims 1 to 12 where a pressure activated spark-plug is used for ignition in an internal combustion powered drill or breaker.

14. A "drill" constructed and arranged or adapted to be operated substantially as hereinbefore particularly described, with reference to and as illustrated by the accompanying drawings.

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